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# Research on Asymmetric Mapping Based Model and Method of Collaborative Design*

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**Abstract**

Aiming at the character that is the limited mobile terminal resources joining in collaborative design in ubiquitous environment, we propose the model of asymmetrical collaborative awareness, the mechanism and the corresponding method for keeping the logical consistency of shared working space. By the topology mapping of views of shared working space, it makes that the mapping area in asymmetrical mapping is only the current possible considerable content of terminals with limited resources, reduces the demanded resources for collaborative awareness. At the same time the maintenance of data consistency of awareness views is implemented by acquirement mechanism according the demand.



*Keywords:* Consistency; Ubiquitous compute; Awareness; Collaborative design.

## 1. Introduction

Awareness is the important support of on-time collaborative design. WYSIWIS (What You See Is What I See) mechanism [1] based-on multi collaborative terminals guarantees the maximization of awareness data. Collaborative systems based-on the WYSIWIS awareness methods are all on isomorphic flat. But, in ubiquitous environment the performances (such as calculation ability, saving ability, display ability, reliability and band width of connecting network, and so on) of isomerous calculation equipments which participate in on-time collaborative design are different. The terminals with limited resource can't

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use old awareness methods to construct and display the awareness information. Therefore, it has important practical meanings to do research on constructing and displaying the awareness contents of different types of terminals in ubiquitous environment.

In recent years, effective awareness technologies adapting to isomerous flats have been paid attention to by scholars on a few fields, such as general calculation, distribution calculation, CSCW and so on. Ma etc. [5] implement the display of mobile terminals by compressing technologies. In collaborative editing system, Jiang etc. [6] transfer video information of mankind face in video meetings to be on-time cartoon avator by tracking mankind face and picking up characters. In collaborative editing system, Correa and Marsic [2][3], Li and Rui [4] did researches on the mutual-operation of different collaborative terminals which share data and have many types of token in the isomerous system. In 2D and 3D collaborative editing application environment, [3] displays sharing editing data by different types of token on isomerous equipment terminals according to the difference of gettable calculation resources and communication resources. [2] proposed the method which is to use structure mapping of sharing data diagram to simplify mapping of picture-with-loss of data and its structure on every terminals in the isomerous system. The mapping mechanism only aims at a kind of specific equipment and eliminates and transfers 3D objects by mapping. This paper proposes the Asymmetrical Collaborative Awareness in collaborative design[7, 8]. By analyzing the topology structure of hierarchy of objects in the collaborative shared working space, the logistic consistency between awareness information on mobile terminals and collaborative terminals with abound resources is implemented by picture mapping of awareness space. Then the method is proposed to maintain the consistency of awareness information, and implement collaborative awareness based-on same semantic and maintaining consistency according to demands on collaborative terminals with limited resources.

## 2. Shared working space in collaborative design

In ubiquitous environment, collaborative design system based-on shared working space can be (S, U, D), where, S is the shared working space of multi-users cooperation, U is the user set who participates in the collaborative work, D is the equipment set which participates in the collaborative work. In shared working space S, there exists a serial of objects O which can be operated by users U. There is a kind of hierarchy relationship between these objects to form the topology structure of shared working space. In Fig 1, the topology structure of shared working space is a kind of tree structure, where, on difference hierarchy, type document of object is Doc, Layer, object group (Grp), and cell object (Obj). Cell object is the minimal editing unit of shared working space, such as beeline, rectangle, bitmap and so on. Document may be constructed by one or multi-layer and these layers overlay front and back. In hierarchies it may exist 0 or multi object group which may be constructed directly by cell objects or containing sub-object groups. Cell object may be subjected to cell object on upper layer. The subordinate relationship may be a kind of semantic subordinate.

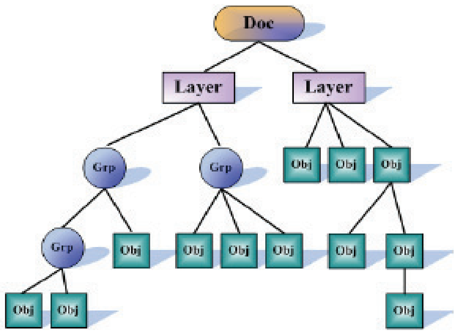


Fig . 1 Topology structure of tree type of document in shared space

**Definition 1** In shared working space, state S=(O, R) , O={oi | 0≦ i ≦ n} is the object set in shared working space, n is the quantity of objects. R is the restriction relationship between objects or on objects.

Objects have some characters attributes A, A = (type, value), type is the type of characters; value is the value of characters. The attributes characters of objects usually include geometrical characters (such as size, position, proportion and so on), color characters and the characters which are defined by users, such as specific semantic etc. The restriction relationship between objects can contain subordinate restriction, geometrical restriction, existing geometrical etc. Subordinate restriction is the relationship of containing and being contained between objects, for example, Grp must be contained by Layer; eye of cell object is subordinated to face of cell object. Geometrical restrictions decide the restriction relationships of relative position in 3D space between objects, such as the restriction relationship between horizontal positions of two eyebrows, the restriction relationship of front and back on the depth direction between front object and background object. However the restrictions usually are caused by practical semantic, for example, two eyes must be on the view at the same time[9].

In the shared working space S, there is the object set O which can be edited or operated by a group of users. In the shared working space S, user U can create, delete, move objects, modify the character attributes of objects, define objects or the restriction relationships between objects.

## 3. Awareness mapping in the shared working space

From the awareness views, the awareness mapping in the shared working space is mainly the mapping of topology token. The mapping of topology token is to simplify the state diagram of the original shared working space by changing the topology structure of diagram, and use it as the state diagram of the objective work space. It mainly includes three kinds of topology token mappings: sub-diagram mapping, integration mapping of vertex and contracted mapping of route.

Set G is the topology structure diagram corresponding to state S in the shared working space. V(G) is the vertex set of diagram G. E(G) is the set of borders. P(G) is the set of routes (which's length is 1).

Sub-diagram mapping fs is to construct a objective terminal sub-diagram GD from original terminal diagram G0. Set vk∈V(G0), vk.ancestor is the ancestor vertex of vk，vk.type is the type of object containing vk. Sub-diagram mapping fs satisfies the following restrictions: if GD is the sub-diagram of G0, fs (G0) = GD , it is that GD is the isomorphic diagram of G0.

(1) If exists r∈R, and r acts on G0', r acts on GD;

(2) If vk.type = "Doc", fs (vk) ∈V(GD);

If fs (vk) $\in$V(GD), v1$\in$V(G0) and v1 = vk.ancestor and v1.type = "Layer", fs (v1) $\in$V(GD).

Sub-diagram mapping is the simplest mapping between original terminal and objective terminal in the shared working space. The method filters information in the shared working space under restrictions. Fig 2 is the typical sub-diagram mapping. In Fig 2, right object group and the three objects objected to the object group are interested by the user on the objective terminal, and the paper define the restriction relationships between the tree objects, then the three objects still exist after mapping. Because object group and cell object in collaborative work in the shared working space can't exist without document and layer, document object and layer object containing object group or cell object in sub-diagram mapping must be mapped. Sub-diagram mapping usually is used in the two fields: (1) acquirement of some layers and subordinate objects which are paid attention to by a document; (2) acquirement of objects in a document area which are paid attention to.

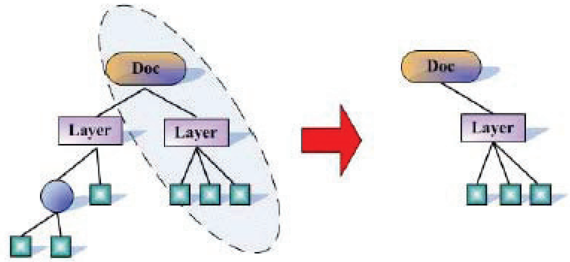


Fig. 2 Sub-diagram mapping

Compressed mapping of vertex fc is to compress the some vertex sub-set of vertex set V0 of original terminal diagram G0 to be a new vertex to get a objective terminal sub-diagram GD . v1, v2,…, vn $\in$V(G0), fc(v1) = fc(v2) = …= fc(vn) = v'$\in$V(GD)，and v' contains the semantic and the correlative restriction relationships of v1, v2,…, vn .

Integration mapping of vertex is to compress some relative concentrative or global vertex set to be a new vertex. These compressed vertexes need to be combined, which are correlative on semantic, or according to the demand. Vertex integration is one of usual mapping methods in collaborative work. In Fig 3, two objects in the left oval shading are compressed, and in the sub-diagram after mapping, its semantic is compressed into the new object. For example, if the type of integration object is the layer object, the objects under the every relative layer are all in the new layer after integrating and the overlapping restriction relationships of forth and back of the integration objects are maintained. If the integration objects are cell objects, the new cell object usually is a new object on semantic after integrating. For example, after integrating two eyes, it can form a rectangle to delegate a pair of eye on the objective terminal, and set the semantic attribute to be "a pair of eye".

Integration mapping of vertex is usually used in: (1) Layer combination. The restriction relationships of forth and back of layers combined are transferred to be the restriction relationships of forth and back on depth direction of objects contained by integrated layers. (2) Object group combination. (3) Cell object joins into object group. (4) Semantic abstraction of complex cell object set, which is that, semantic frame delegates abstractly the contained cell objects to reduce the resources used by cell objects.

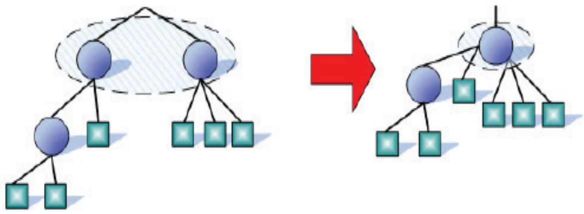

Fig. 3 Integration mapping of vertex

Contracted mapping of route fr is to combine the routes of sub-set which satisfy the following conditions of P(G0) in the original terminal diagram G0, to make them to be a border, to get the objective diagram GD.

(1) The length of the route can't less than 2, it is that the route must have at least three vertexes;

(2) The degree of the inner vertexes of the route is 2, which is that there is only two borders connecting the vertes;

(3) If vk∈V(G0), and vk.type = "Layer", vk can't be contracted.

If e1, e2,…,en∈E(G0), e1, e2,…,en construct the route p, fr(e1) = fr(e2) = … = fr(en)=e' ∈E(GD). The two vertexes of e' satisfy the subordinate restriction relationships in the original diagram and e' contains the semantic and restriction relationships of the middle vertexes of p.

Contracted mapping of route is to combine those hierarchy relationships to be simple and clear single relationships. As Fig.4 shows, if users are not interested in objects in the oval shading, users can compress and omit them. However, the restriction relationships between the semantic of the omitted vertexes will be integrated on the new border. Contracted mapping of route usually ignores the middle details to reduce the resources used by objects in the route.

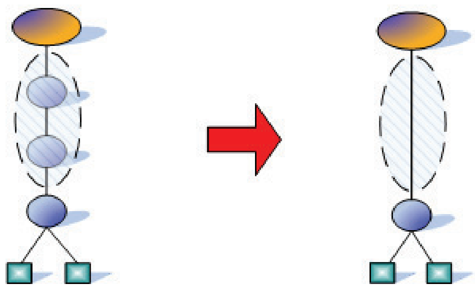

Fig. 4 Contracted mapping of route

Multiplex topology mapping fm = f1⊙f2⊙…⊙fn, where, f1, f2, …, fn ∈{fs | fc | fr}. Multiplex topology mapping is the composition of the above three topology mapping.

The awareness mapping in the shared working space can solve the collaborative difficulty of every collaborative terminals in the ubiquitous environment which be brought by the unbalance between calculation resource and communication resource. But, from the above result of awareness mapping, we know that topology structure and even the objects themselves of the original diagram and the objective diagram changes[10]. Therefore, there is inconsistency between data structure and content in shared working space on different collaborative terminals, and collaborative operation on different terminals can cause different results and at last it will cause the harassment of the collaborative awareness, the unusable of the collaborative system and the failure of the collaborative work.

It is different to the consistency maintenance in the shared working space of the conventional collaborative system. In the ubiquitous environment, the consistency maintenance of awareness information in the shared working space is not that it can't maintain the consistency of data. The consistency maintenance of asymmetrical collaborative awareness is to keep the semantic consistency when keeping the every terminals effective cooperation under the awareness mapping mechanism. At the same time, the system use the consistency maintenance method which is to draw according to the demand, which is that the system gets correlative information on-time from original terminals of the sharing working space when the terminals with limited resources need the more detailed views with the absolute consistent data.

## 4. Example

We implement CoDesign collaborative design system, which supports desktop and PDA to do collaborative edit. CoDesign mainly edits pictures, implement the basic picture editing tools, support picture and photo to do collaborative edit, offer the collaborative tools in video meetings, chat and white block and so on. The correlative model and technology in the paper have been implemented and proved in CoDesign prototype system.

In the experiment, collaborative terminals are PC or PDA simulator. Dell PC use 17'' CRT display which's resolution ratio is 1024x768, 2.4G CPU, windows XP or above operation system. PDA collaborative terminals operate as Pocket PC simulator of Windows CE on Dell PC with the same configure, or Nokia Symbian OS simulator.

In Fig 5, it is to design and browse kerchief by multi-users. The desktop user designs, and PDA user mainly browse pictures, communicate with PC by phone, or edit or annotate by simple editing tools. In Fig 5, PDA only maps the pictures of the middle area.

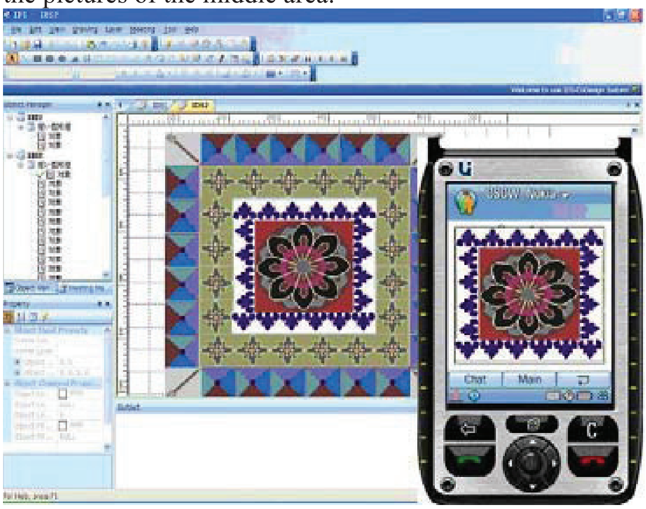


Fig. 5 The example of perceiving mapping

## 5. Conclusion

The paper proposes the asymmetrical awareness based-on mapping, which maps the content of the terminals with abound resource in the shared working space to the terminals with the limited resource according to some rules. The mapping implements the mapping of awareness view under satisfying the many kinds of restrictions. The paper builds the collaborative awareness based-on the asymmetrical semantic consistency between the collaborative terminals, and implements the consistency maintenance of all data based-on drawing according the demand.

## Acknowledgment

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